Using Concept Maps on the World-Wide Web to Access a Curriculum Database for Problem-Based Learning

Timothy B. Patrick, Ph.D.[1,2], Eugene R. Worth, M.D.[2], Laura E. Hardin, D.V.M., M.S.[2]
[1]School of Library and Information Science, [2]Medical Informatics Group
University of Missouri-Columbia

Development of medical school curriculum databases continues to be challenging. Representation of the instructional unit is becoming increasingly difficult due to characteristics of the problem-based learning (PBL) curricula. Curriculum databases may be used to store materials for the PBL curricula, and also to provide a delivery mechanism for those materials. However, in order to take advantage of the curriculum database as a tool for PBL, methods for accessing the curriculum database that are better suited to the information needs of students, faculty, and administrators must be developed. Concept maps are directed graph representations of conceptual relationships, and may be used to represent the content of a curriculum database. In this paper, we describe a Web application that uses Java-based concept maps as the user interface to a curriculum database.

INTRODUCTION

Problem-based learning (PBL) is a constructivist approach to medical education. It has been argued that PBL may be used to promote contextual learning, activate prior knowledge, increase intrinsic learner motivation, and promote self-directed learning.[1] PBL, by nature, crosses departmental boundaries, especially in the pre-clinical curriculum. Patient oriented cases form the core of PBL instructional units. These characteristics of PBL pose new challenges for students, faculty, and administrators. PBL has important implications for instruction, as well as for the development and maintenance of curricular content. A curriculum database can maintain instructional content as well as allow access to, and tracking of, curriculum data.

When developing a curriculum database, one must address the *representation problem*.[2] The representation problem is one of providing an interface to the database that is well-suited to the information needs of the intended users.

Concept maps[3] are visual representations of conceptual relationships. Concept maps are hierarchical in nature but not limited to linear forms. They encourage demonstration of relationships between concepts rather than presenting long lists. Concept maps have effectively represented an integrated veterinary curriculum at Cornell University.[4]

In this paper, we describe a Web application that uses Java-based[5] concept maps as the user interface to a curriculum database. This concept map interface allows us to address the representation problem by configuring the interface to the requirements of the intended users, e.g., students.

SYSTEM DESIGN

The system has three components: (1) a curriculum database; (2) a collection of simple markup language descriptions of concept maps; and (3) a Java applet that takes the markup descriptions of concept maps as input, draws the maps and renders them functional.

Curriculum Database

The curriculum database is organized by *curriculum blocks*, *cases*, *main categories*, *subcategories*, *concepts* and *concept datasets*. Each block consists of one or more cases. Each case consists of a standard set of main categories (e.g., *History* and *Physical Exam*). Each main category consists of a standard set of subcategories (e.g., *Complaints* and *Past History*). Each subcategory is associated with one or more concepts (e.g., *Spousal Abuse*). Each concept is associated with a concept dataset. Each concept dataset consists of patient data, learning objectives, and one or more informational resources. The learning objectives are derived from the United States Medical Licensing Examination (USMLE).[6] The informational resources may or may not be available in digital form.

Figure 1 depicts a typical slice of the curriculum database. *Block 1* contains *Case 1: 35 Year old woman. Case 1* contains the main category *History. History* contains the subcategory *Past History. Past History* contains the concept *Spousal Abuse. Spousal Abuse* is associated with a concept dataset consisting of patient data concerning ER visits, learning objectives concerning psychosocial matters, and a graphic image of a bruised woman.

0195—4210/96/$5.00

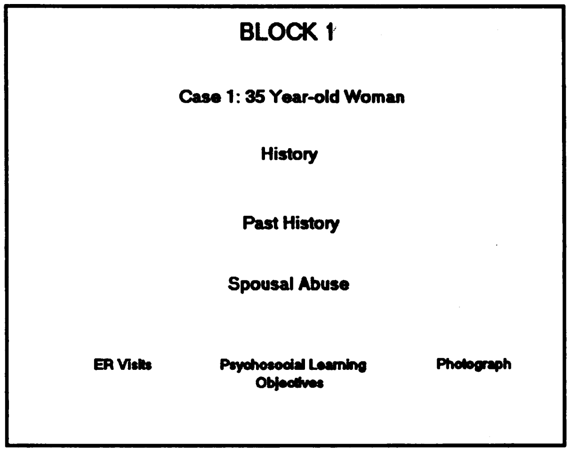

Figure 1: The Curriculum Database

Concept Maps

The main categories of a case (e.g., *History*) are represented by concept maps. The concept map for a main category depicts its subcategories (e.g., *Complaints*), and the concepts, concept datasets, and conceptual relationships associated with the subcategories.

Concept maps are represented as graphs consisting of nodes and arcs. The nodes typically represent concepts and the arcs represent relationships. We describe our concept maps in a simple markup language that specifies the:

- map label;
- node coordinates;
- node type;
- node label
- node Uniform Resource Locator (URL);
- arc coordinates; and
- arc label.

Figure 2 shows the markup language representation of a partial concept map for Case 1 *History*.

```
<applet align=top code="map.class" width=750
height=400>
<param name=side value="100">
<param name=label value="History">
<param name=nodes value="#1;325-40,Complaints+
=&#0;430-120,Pregnancy+=
&http://kbot.mig.missouri.edu:443/cgi-shl/dbml.exe?
action=query&template=/curic/history.dbm&node_i
d=4#0;300-230,Alcohol+and
Fetal=Development&http://kbot.mig.missouri.edu:4
43/cgi-shl/dbml.exe?action=query&template=/curic/
history.dbm&node_id=7#1;300-325,Social History+
= & ">
<param name=arcs value=
"375-90,480=120$#350-325,350=280$#350-230,480=
170$abnormally affects">
</applet>
```

Figure 2: Markup of Partial Concept Map for Case 1 *History*

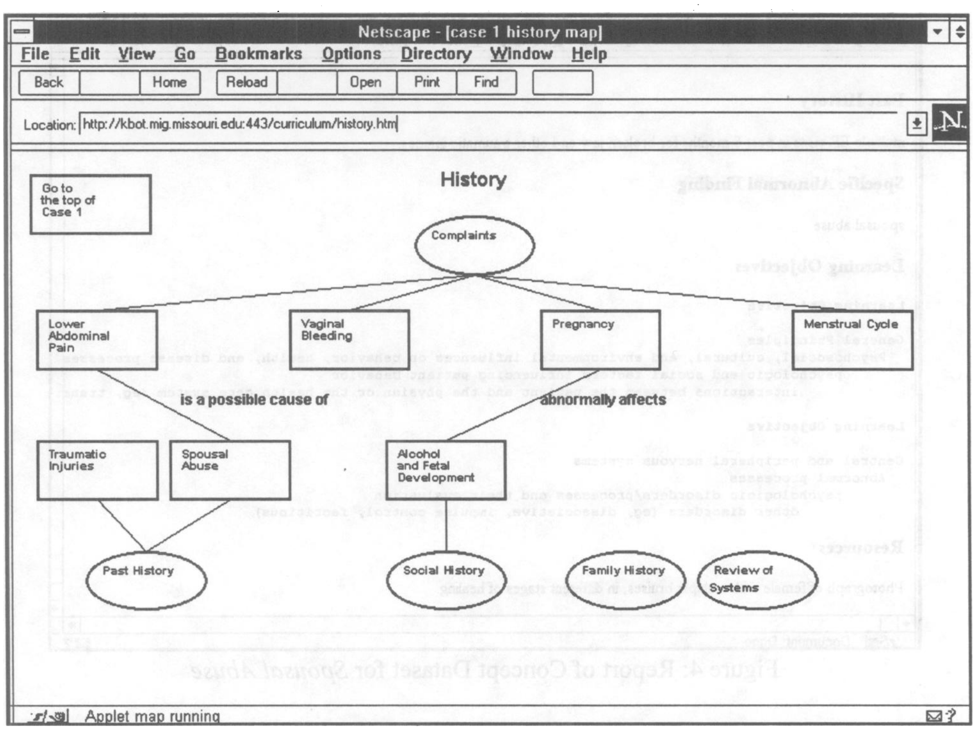

Figure 3: Concept Map for Case 1 *History*

Figure 3 depicts the full concept map for Case 1 *History*, as drawn by the Java applet. There are two types of nodes. The oval nodes are *subcategory* nodes. They are not functional, that is, they are not associated with a URL. The rectangular nodes are *concept* nodes. Concept nodes are functional and provide access to a concept dataset. Each concept node is associated with a URL that is a CGI request for an SQL query against the curriculum database. The SQL query returns a report of the appropriate concept dataset. The report includes patient data, learning objectives, and informational resources associated with the concept. Figure 4 depicts the report for the *Spousal Abuse* concept dataset.

Typically, a subcategory (oval) node will be connected to one or more rectangular concept nodes. In some cases, however, no concepts or data may be associated with the subcategory node. In Figure 3, neither of the subcategories *Family History* or *Review of Systems* are associated with any concepts or data.

The arcs are not functional, that is, are not associated with any URL. Unlabeled arcs represent database relationships. Labeled arcs represent conceptual relationships. For example, the arc from *Alcohol and Fetal Development* to *Pregnancy* represents the conceptual relationship *abnormally affects*.

It is important to note that a concept map such as the one shown in Figure 3 will not depict all of the possible relationships among concept nodes. The map will only include those conceptual relationships considered important by the faculty curriculum designer.

Java-based Concept Maps
A simple Java applet, based on the Java graphics methods, is used to draw the concept maps. As the user clicks on a concept node, this applet is also used to process the URL associated with the node.

DISCUSSION

Strengths of the System
Ease of Use. Students involved in a medical PBL curriculum are expected to develop an extensive medical knowledge base while concurrently developing problem-solving skills to apply in clinical situations. While this approach provides many positive aspects for the student, managing the content can be an overwhelming task. Our use of a concept map interface to the curriculum database will allow diagrammatic, hierarchical and relational representation of key elements of each clinical case in the curriculum. We believe that this interface will allow students to evaluate the components of a clinical case, without having to rely on artificial structures such as outlines and lists. In short, we believe that our concept map interface will make it easy for the students to use the curriculum database.

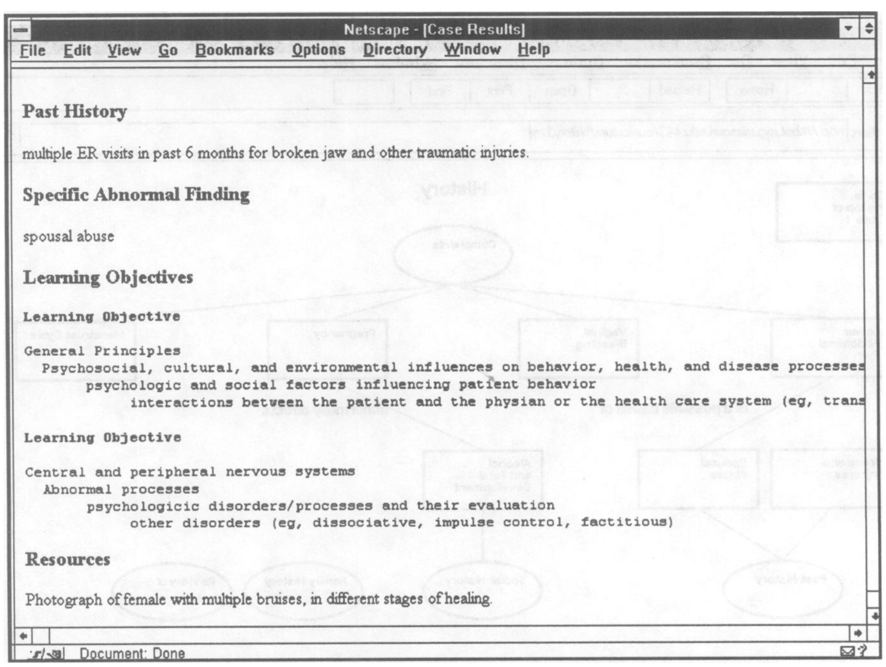

Figure 4: Report of Concept Dataset for *Spousal Abuse*

Configured Views. More important than its ease of use, however, is the fact that a user interface based on concept maps will allow for *configured* views of the curriculum database. A configured view of the curriculum database is one that is uniquely tailored to the needs of particular users. We hypothesize that our concept map interface will allow us to address the *representation problem* in an effective way. The intended users of the curriculum database are not just students. Faculty and administrators also require access to the curriculum database. We can address the interface needs of each group with concept map interfaces tailored to their needs. One set of concept maps will address the needs of students. Another set of concept maps will address the needs of faculty, and still another set will address the needs of administration.

Configurable Workstation. We think it is reasonable to keep the markup language description of concept maps intended for students in the curriculum database. After all, the logical design of the maps is essentially a pedagogic matter. More generally, we think it reasonable that all such markup versions of concept maps be stored in the database.

The possibility of storing different views of the curriculum database in the database itself suggests an interesting notion: that of a *configurable workstation*[7]. Our user interface based on concept maps provides the basis for a configurable workstation as a point of access into a distributed information resource (e.g., a distributed electronic patient record[8].) The concept map interface represents a view of the curriculum database suited to the needs of particular users. Similarly, the configurable workstation based on concept maps may provide a view of the information resource suited to the needs of the user. For example, a *dentist* could be presented with a different view of the distributed patient record than would an *internist*. At login time, the user's role in the institution would be determined and the workstation configuration appropriate to that role (ie., the concept map interface) would be retrieved from the database and rendered functional.

The configured view (or concept map) is stored in the information resource (or database) as an information object in its own right. In this way, configured views of the information resource (or database) are akin to secondary sources in the traditional library: they provide a way to view and make use of other objects in the information resource.

While it is doubtful that our Java-based concept maps would prove sufficiently powerful to support all aspects of such a configurable workstation, we think that they do provide an interesting point of departure for its development, and a mechanism for rapid prototyping.

Weakness of the System

Dynamically Constructed Maps. A current weakness of our system is its inability to dynamically construct markup representations of concept maps. To be sure, our Java-based maps are drawn as needed. We do not rely on HTML image maps and previously drawn graphics files to implement our concept maps. Yet, even so, a markup language representation of each map must be constructed in advance. This limitation has two implications. First, it may prevent us from being able to provide views of the curriculum database that are in some non-trivial way related to the current *state* of the user. Second, it may prevent us from being able to fully support the constructivist paradigm[9], according to which the individual constructs his or her own view or understanding of the information.

Regarding views related to student *state*, suppose it is useful to reveal to the student certain parts of the curriculum only after the student has investigated certain other parts of the curriculum. A straightforward state interaction would provide an interface that would allow the student to see Case 2 only after completing Case 1. That level of state interaction could be addressed by our current system. However, a more sophisticated state interaction would require a mechanism for dynamically constructing markup representations of concept maps. For example, suppose that Case 1 and Case 2 are related. The view of Case 1 initially provided to the student is shown in Figure 5.

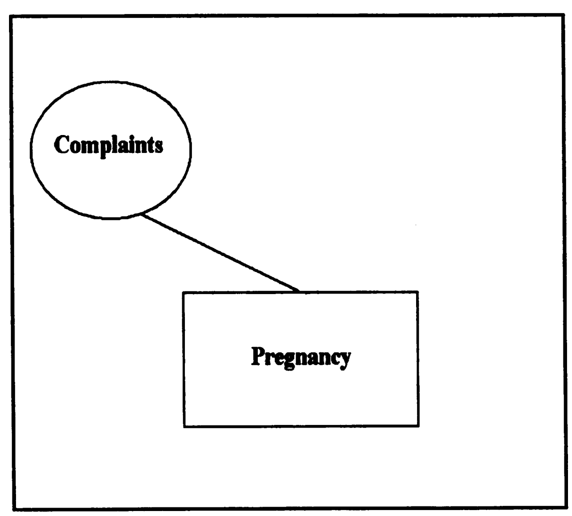

Figure 5: The Student View of Case 1 Before Visiting Case 2

Figure 6 shows the view of Case 1 provided to the student after the student has investigated the concept of *Down's Syndrome* in Case 2. The view of Case 1 (ie., the student concept map interface) has been dynamically altered to reflect the student's experience with Case 2.

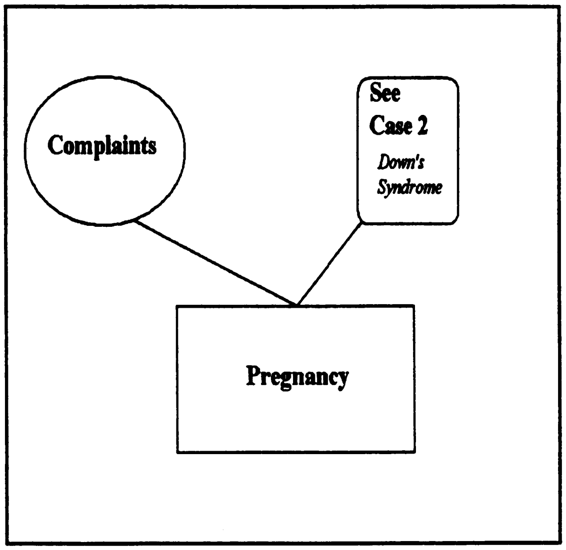

Figure 6: The Student View of Case 1
After Visiting Case 2

Support for the constructivist paradigm may be achieved by giving the student the ability to alter the view of the case provided. For example, the student could remove the path to the concept *Down's Syndrome*, and might replace it with a link to another concept, perhaps from some other case.

CONCLUSION

In order for a curriculum database to provide worthwhile access to instructional materials, the representation problem for the intended users must be addressed. We think that our prototype of a concept map interface to the curriculum database allows us to address the representation problem by providing views of the curriculum database that are easy to use and that are tailored to the information needs of types of users. However, more formative evaluation (e.g. trial implementation, focus groups, and user satisfaction surveys) is required to verify the system's ability to address the representation problem.

Acknowledgments

This work was supported, in part, by grants LM07089 and LM05415 from the National Library of Medicine.

References

1. Dolmans DHJM, Gijselaers WH, Schmidt HG, and Van der Meer SB. Problem effectiveness in a course using problem-based learning. *Acad Med* 1993. 68:207-213.

2. Nowacek G, Friedman CP. Issues and challenges in the design of curriculum information systems. *Acad Med* 1995, :70:1096-1100.

3. Novak JD, Gowin DB. *Learning how to learn.* New York: Cambridge University Press; 1984.

4. Edmondson KM. Concept mapping for the development of medical curricula. *J Res Sci Teach.* 1995, 32:777-793.

5. Van Hoff A, Shaio S, Starbuck O. *Hooked on Java.* Reading: Addison-Wesley Publishing Company; 1995.

6. United States Medical Licensing Examination. 1995. The Federation of State Medical Boards of the United States, Inc. and the National Board of Medical Examiners (NBME).

7. The term is due to Joyce A. Mitchell, David Witten, J. Craig Klimczak, and Timothy B. Patrick.

8. The idea of using concept maps as selective views of the distributed electronic patient record was proposed by Allen Hahn in conversation with the authors.

9. Lebow D. "Constructivist Values for Instructional Systems Design: Five Principles Toward a New Mindset". In: *Instructional Design Fundamentals: a reconsideration*, Seels B, ed. Englewood Cliffs: Educational Technology Publications, Inc.; 1995.